

REMARKS

Claims 1-28 are pending in the application. Claims 1-28 stand rejected pursuant to a non-final Office Action mailed April 30, 2009. Each of the pending claim rejection is rebutted in detail below.

I. Claim Rejection-35 U.S.C. §102

Claims 1-3, 5-10, 12-13, 17-18, 20-26 and 28 stand rejected under 35 U.S.C. 102(e) as being anticipated by Buchold et al. (U.S. Pat. 7,158,552). The Buchold prior art reference discloses a fiber grating diode laser which includes feedback apparatus to reduce relative intensity noise (RIN). On the contrary, the embodiments claimed by Applicant recite an optical device and method for averaging mode noise induced signal level variations in light propagating within a multi-mode optical fiber. Mode noise and RIN are entirely different phenomenon. In addition, the Buchold apparatus reduces noise and the claimed apparatus averages noise without reducing it. Applicant recognizes that the foregoing observations do not by themselves require the allowance of the pending claims. It is important however to understand the nature of these two separate types of optical noise in order to appreciate the clear distinctions which render the pending claims patentable over the Buchold reference.

RIN is a measured range of variation in the optical power of a laser. The optical power of a laser is not entirely constant. In the contrary, optical power can be considered to have an average value within a range of optical powers fluctuating around the average value. RIN is commonly defined as the variation or fluctuation of the average optical power divided by the average optical power. A more comprehensive definition of RIN is included in Exhibit A, attached hereto, which is a short article from the Encyclopedia of Laser Physics Technology.

A fiber grating wavelength stabilized laser includes a laser diode and a fiber grating. Light within a selected wavelength range emitted by the diode laser is in part reflected back to the diode by the grating. This increases the gain of the laser. As described in detail in the Buchold reference, the RIN of a fiber grating wavelength stabilized laser is closely related to the difference between the laser diode gain wavelength peak and the reflection wavelength peak of the fiber grating (see abstract.) As noted at the top of column 4 of the Buchold patent, the inventors therein determined that the larger the separation between the gain peak of the laser diode and the reflection peak of the fiber grating, the higher the RIN. Thus, to lower RIN the Buchold inventors developed a system where optical feedback from the grating is tapped and

measured to determine the separation between the gain peak and the reflection peak. A controller analyzes the feedback signal and makes adjustments to the laser diode output to minimize the separation between the gain peak and the reflection peak; thereby reducing RIN.

In one embodiment, as described at column 6, line 44-55, the adjustment to the laser diode output may be made by controlling the injection current to the laser diode. In an alternative embodiment, described at column 6, line 58-62, the wavelength of the gain peak is controlled directly by adjusting the temperature of the laser diode with a thermo-electric cooler. It is critical to note that the Buchold reference is strictly limited to a controlled and precise temperature adjustment in response to optical feedback.

On the contrary, Applicants' claimed embodiments feature the cyclical manipulation of a multi-mode fiber optic to time average mode noise induced signal variations. Buchold does not teach or suggest any type of cyclical manipulation or signal averaging and is thus not an anticipatory reference.

Furthermore, if a cyclical temperature adjustment or noise averaging were applied to the Buchold apparatus, said apparatus would be completely dysfunctional. As noted above, Buchold relies upon optical feedback to precisely match a laser diode gain peak with a fiber grating reflection peak thereby reducing RIN. Clearly, the cyclical application of power or the cyclical implementation of a temperature change would defeat the purpose of trying to match the gain and reflection peaks according to observed optical feedback to reduce RIN. Cyclical temperature manipulation and noise averaging would quite possibly increase RIN.

All embodiments claimed in the pending application feature cyclical manipulation of a fiber to average mode noise. In particular, as stated at paragraphs [0056]-[0057]:

"As shown schematically in FIG. 3, the cyclical phase shifting or scrambling of modal noise to produce a time averaged measurement may be accomplished with an optical device 300... The optical device 300 will also include an averaging component 308 operatively associated with the multimode fiber 302. The averaging component 308 may include apparatus for cyclically varying an index of refraction of the multimode optical fiber 302 over a select period of time. Alternatively, the averaging component 308 may include an apparatus for scrambling a light distribution within the multimode optical fiber 302. Variation of an index of refraction or scrambling a light distribution may be accomplished by the averaging component 308 through cyclically varying the temperature of the multimode optical fiber 302, cyclically manipulating the multimode optical fiber 302, or both."

Applicant has determined that cyclical temperature or mechanical variations to average mode noise are useful for applications such as tunable diode laser absorption spectroscopy (TDLAS). See, for example paragraph [0043] of the application.

It is extremely important to note that Applicants' claimed apparatus and method do not reduce or eliminate mode noise. On the contrary, the effects of mode noise are averaged or scrambled and thus made less detrimental to the overall goal of a system, for example, a laser absorption spectroscopy system.

In summary, the Buchold reference teaches the precise feedback-based adjustment of the temperature of a diode laser to tightly control the gain peak of a diode laser. If the gain peak of the diode can be matched to the reflection peak of an associated grating, RIN is reduced. Buchold does not feature any type of cyclical manipulation or noise averaging. Furthermore, any possible cyclical manipulation or averaging implemented with the Buchold apparatus would be counterproductive to the goal of precisely adjusting a laser gain peak to match a grating reflection peak thereby reduce RIN.

Accordingly, Applicant respectfully submits that Buchold does not teach or suggest the following elements of selected claims and is not an appropriate anticipatory reference:

- “means for averaging” (claim 1)
- “means for cyclically varying an index of refraction...over a selected period of time or means for scrambling a light distribution” (claim 2)
- “means for cyclically varying the temperature...or means for cyclically manipulating the multi-mode optical fiber” (claim 3)
- “cyclically varying an index of refraction of the multi-mode optical fiber” (claim 7)
- “cyclically varying the temperature of the multi-mode optical fiber...or cyclically manipulating the multi-mode optical fiber” (claim 8)
- “a thermal element in thermal contact with the multimode optical fiber providing for the cyclical variation of a temperature of the multimode optical fiber” (claim 12)
- “(a manipulation apparatus operatively associated with the multimode optical fiber providing for the cyclical manipulation of the optical fiber” (claim 18)

- “means for averaging a modal noise induced signal level variation of light propagating within the multimode optical fiber” (claim 24)

Accordingly, applicant respectfully requests that the pending rejection of claims 1-3, 5-10, 12-13, 17-18, 20-26 and 28 pursuant to 35 U.S.C. 102(e) be withdrawn.

II. Claim Rejection- 35 U.S.C. §103

Claims 14, 15 and 16 stand rejected under 35 U.S.C. 103(a) as being obvious in view of Buchold et al.. Claims 14, 15 and 16 depend from claim 12, which features the element of; “a thermal element in thermal contact with the multi-mode optical fiber providing for the cyclical variation of a temperature of the multi-mode optical fiber.” As discussed in detail above, Buchold does not teach or suggest any type of cyclical variation or noise averaging. Thus, claims 14, 15 and 16 are allowable for reasons set forth above with respect to claim 12. Accordingly applicant respectfully requests that the rejection of claims 4, 11, 19 and 27 pursuant to 35 U.S.C. 103(a) be withdrawn.

Claims 4, 11, 19 and 27 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Buchold as applied to claims 1-3 above and further in view of Rabinovich et al. (U.S. Pat 5,841,915). Claims 4, 11, 19 and 27 depend from claims 1, 1, 18 and 24 respectively. The parent claims to 4, 11, 19 and 27 are believed to be allowable for the reason set forth in detail above. Accordingly, claim 4, 11, 19 and 27 are allowable as well.

In addition, the Rabinovich reference relied upon in conjunction with Buchold does not teach the cyclical manipulation of a fiber to average or scramble mode noise. Rabinovich does teach the mechanical manipulation of a fiber to induce mode noise. In addition, the induction of mode noise can be repetitive or cyclical as described in Rabinovich at column 7 and in Fig. 10. However nowhere in Rabinovich is it suggested that mode noise is, can be or should be time averaged. On the contrary, mode noise is introduced in the Rabinovich test apparatus expressly so that the variations in output can be measured. See for example, claim 1 which includes:

“means for determining the effect of said preselected change in the physical condition of said optical fiber on said optical signal as said optical signal is transmitted through said optical fiber between said source and said receiver”

Any manipulation which would average mode noise would negate the ability of the Rabinovich device to measure mode noise induced variations, negating the purpose of the apparatus. Accordingly, applicant respectfully requests that the rejection of claims 4, 11, 19 and 27 pursuant to 35 U.S.C. 103(a) be withdrawn.

For the reasons set forth above, Applicant respectfully submits the claims as filed are allowable over the art of record and reconsideration and issuance of a notice of allowance are respectfully requested. If it would be helpful to obtain favorable consideration of this case, the Examiner is encouraged to call and discuss this case with the undersigned.

This constitutes a request for any needed extension of time and an authorization to charge all fees therefore to deposit account No. 19-5117, if not otherwise specifically requested. The undersigned hereby authorizes the charge of any fees created by the filing of this document or any deficiency of fees submitted herewith to deposit account No. 19-5117.

Respectfully submitted,

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